Simulation and 'what ifs' in the civil estate

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Simulation can be a screening tool

- Others are already delivering better value to clients concerned with the civil estate - buildings that work better, are better places to work, hold archives, present history, make history or conduct research.

- And…there are not very many design teams who do this as well as lots of inertia.

The people in this room have ideas of how the ideas, skills, methods, and tools of the *successful few* can become more widely dispersed.

- Our perspective is from a place where the much of the building stock, including the civil estate, is not new, the replacement rate is low and society has adapted by re-purposing buildings and finding ingenious ways to keep them going.

- ESRU support clients and design teams who are currently working on refurbishment and repurposing projects.

- We are also mentors to companies who want to create in-house capabilities.

- We work closely with the SESG (Sottish IBPSA affiliate) to support technology transfer initiatives.

- ESRU is the core development site for the ESP-r multi-domain simulation environment.

- Ethos of ESP-r - functionality follows description. Additional solvers (air flow, CFD, electrical power) are brought on line as additional information is provided.
- The user chooses the level of resolution for the building, systems, controls, flows.
- Some cutting edge options - fully coupled and adaptive CFD simultaneous with the building thermal solution. It supports several dozen internal heat transfer regimes. Turn on everything at high resolution and micotoxin analysis is possible.
- Works in conjunction with Radiance visual simulation
- Exports a rather 'clean' EnergyPlus model
- Comparison with Blast and EnergyPlus (see paper by Crawley & Hand et al to be published in IBPSA 05 in Montreal)

- Such flexibility is useful for addressing the questions that no one told clients that they could not ask and doing a reality check on the beliefs that design teams want to foist on clients.
- Other 'agents' can generate ranges of 'what if' questions so that useful comparisons can be delivered -
  - Natural Resources Canada web based home energy advisor
  - An architectural firm buried ESP-r under their in-house CAD and QA tools.
- Or to allow the simulation engine to be hidden within a tool which is designed for the needs of a specific audience.
  - A wrapper interface for use by glazing mfg

- Available under GPL license - so anyone can download it and look inside. Anyone can use it for any purpose.
- Anyone can evolve it as long as they share their evolution

  (NRCan is building HOT3000 with it and contributed 60K lines of code in October 204, last week a contaminate model was added by a PhD student)
- It runs on just about any computer and just about any operating system
- There is a world-wide development community
- It is well documented within the code and in associated documentation
- It evolves daily.
- Look at http://www.esru.strath.ac.uk for it.

- So what is this thing called ESP-r….

(live demo at this point)

Renovation…

- Keeping buildings going is a habit in Europe.

- Making it work better over time or helping it adapt to new demands sometimes requires thinking out-of-the-box and simulation is a helpful for this.

- Simulation is a *disruptive technology for design teams* - they work differently when new information is available and which can be explored interactively by the whole design team.

- (been there, watched it happen, seen firms revise their business model afterwards)

Some issues ESP-r has addressed:

- mechanical ventilation vs air conditioning vs natural ventilation as different future options and with minimal disruption designed in (classic future-proofing)
- identify over-specification of glazing system in offices saving both capital, running costs and emissions
- identify discomfort frequency for under-capacity systems as part of a cost-benefit analysis
- test optimal start regimes, optimisers, compensators, night set-backs, local controls under different demand and climate patterns - the usual stuff

- identify over-specification of glazing system in offices saving both capital, running costs and emissions

(live demo at this point)
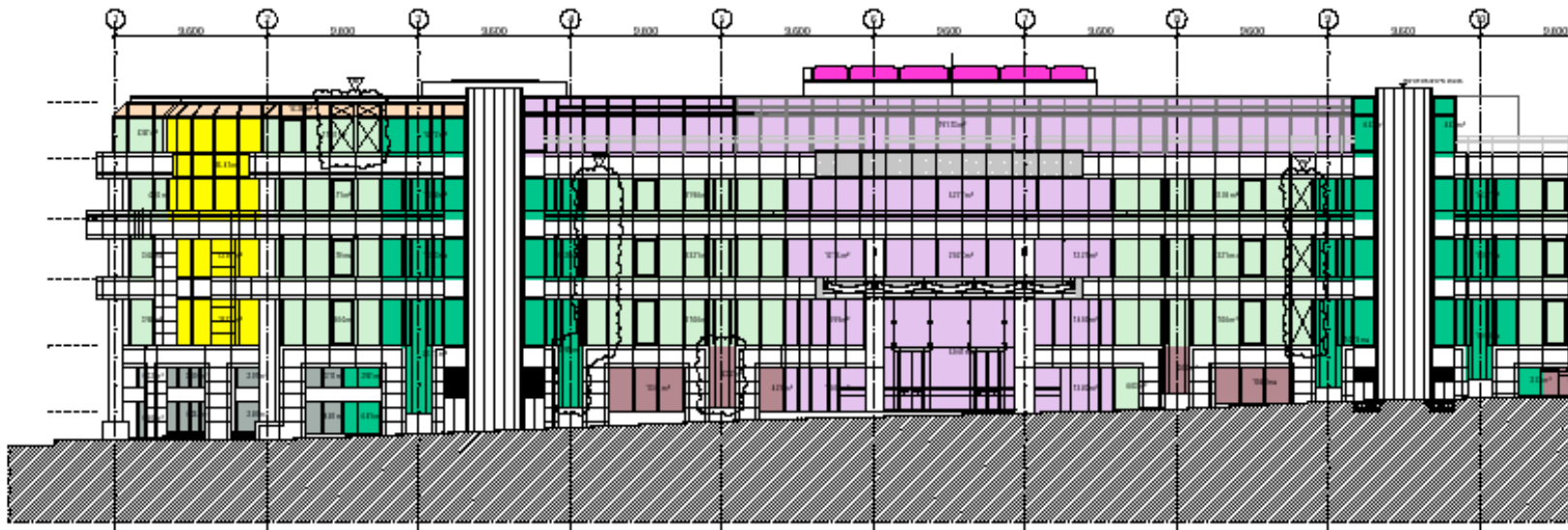
Other issues…

- identify discomfort frequency for under-capacity systems as part of a cost-benefit analysis
- test optimal start regimes, optimisers, compensators, night set-backs, local controls under different demand and climate patterns - the usual stuff
- implications of occupant window opening patterns
  - To test if natural ventilation might work
  - To test if window opening impacts mechanical ventilation

More issues:

- support facade manufactures who
  - attempt to adapt a design for a new region
  - Support their product developmet with virtual trials

DoF_gap3

DoF_gap2

DoF_gap1
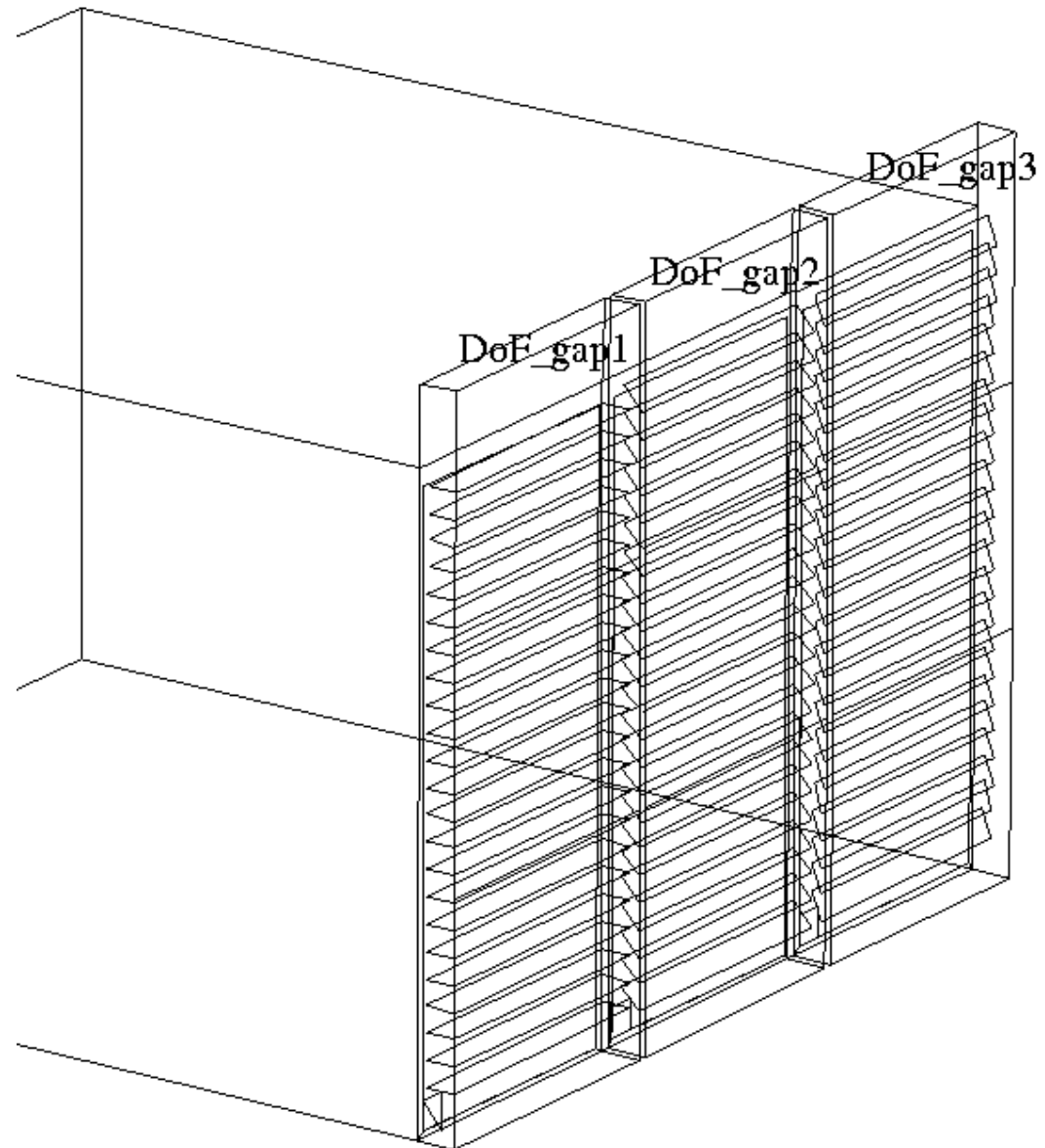
More issues:

- critical placement of phase change materials within rooms
  - (one method contributed by Polish researchers, another under development in Austria)
- design of experimental facilities to minimize adaptation periods between experiments
- embed simulation within a real-time BEMS
  - What if the commissioning simulation model placed in the BEMS could also be used by facilities managers planning changes???
- failure scenarios for environmental systems in museums
- glare assessments for changes in facade designs

More issues:

- dynamic insulation

- earth pipes to temper fresh air supply

- reality checks on double skin facades

- reality checks on facade integrated PV

- Electrochromic glazing

- Co-generation and fuel cells

- design-out humidity controls in a museum archival facility

- A virtual study of the West Bethesda project is a bread-and-butter consulting project

- re-introduction of internal mass to moderate comfort and time-shift peak temperatures

More issues:

- structural cooling and night purge
    - in conjunction with raised floor systems
    - or dropped ceilings
    - or with exposed mass
    - Perhaps using modified smoke extracts
- floor heating systems -
    - Pipes in slab
    - Air ducts in slab
- high temperature linear heaters in high volume spaces
    - Represented as explicit heated surfaces so that full radiant impact is taken into account
    - pity we don't have a good correlation for convective exchange with 300C surfaces
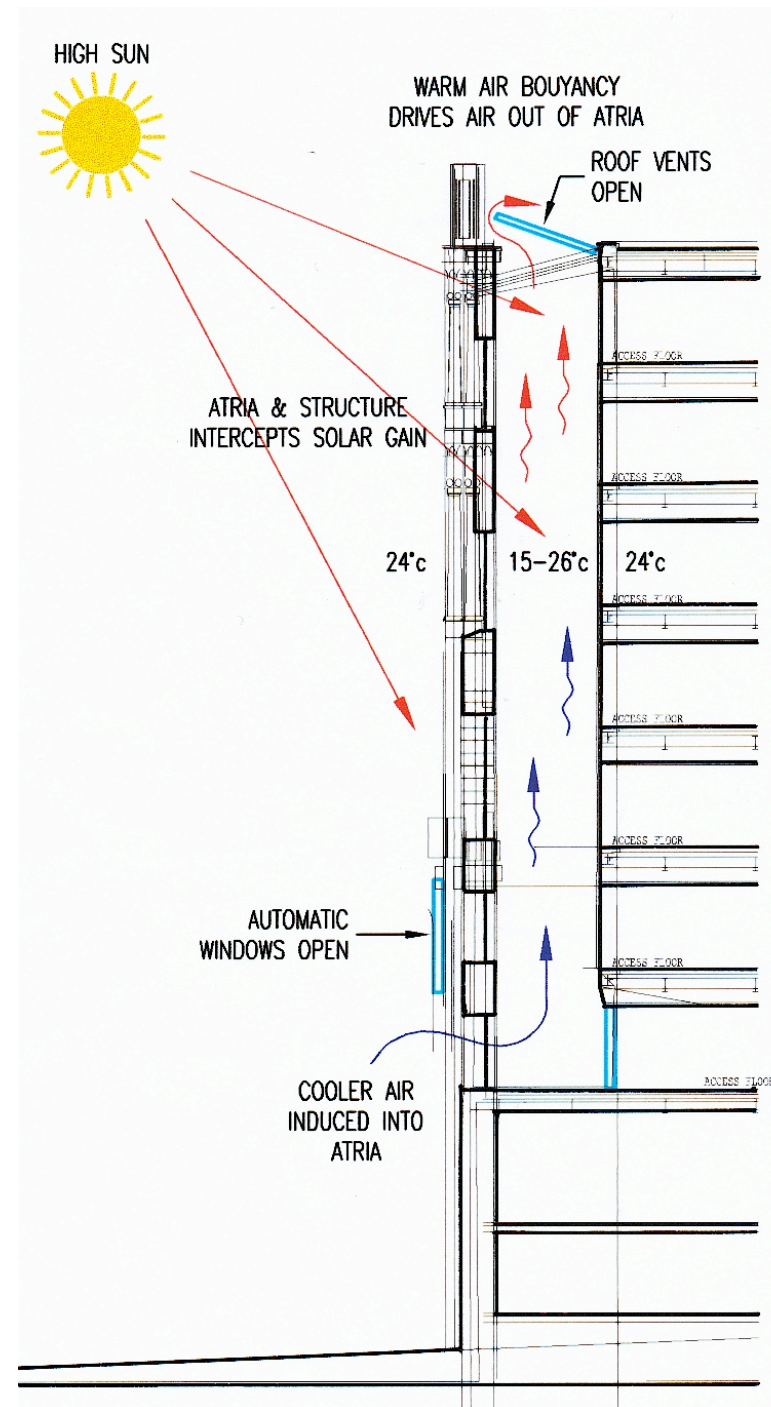- implications of occupant window opening patterns

More issues:

- Assessment of a reversed double skin facade - using historical facade as the outer skin
- Re-purpose of building from a post office to office space
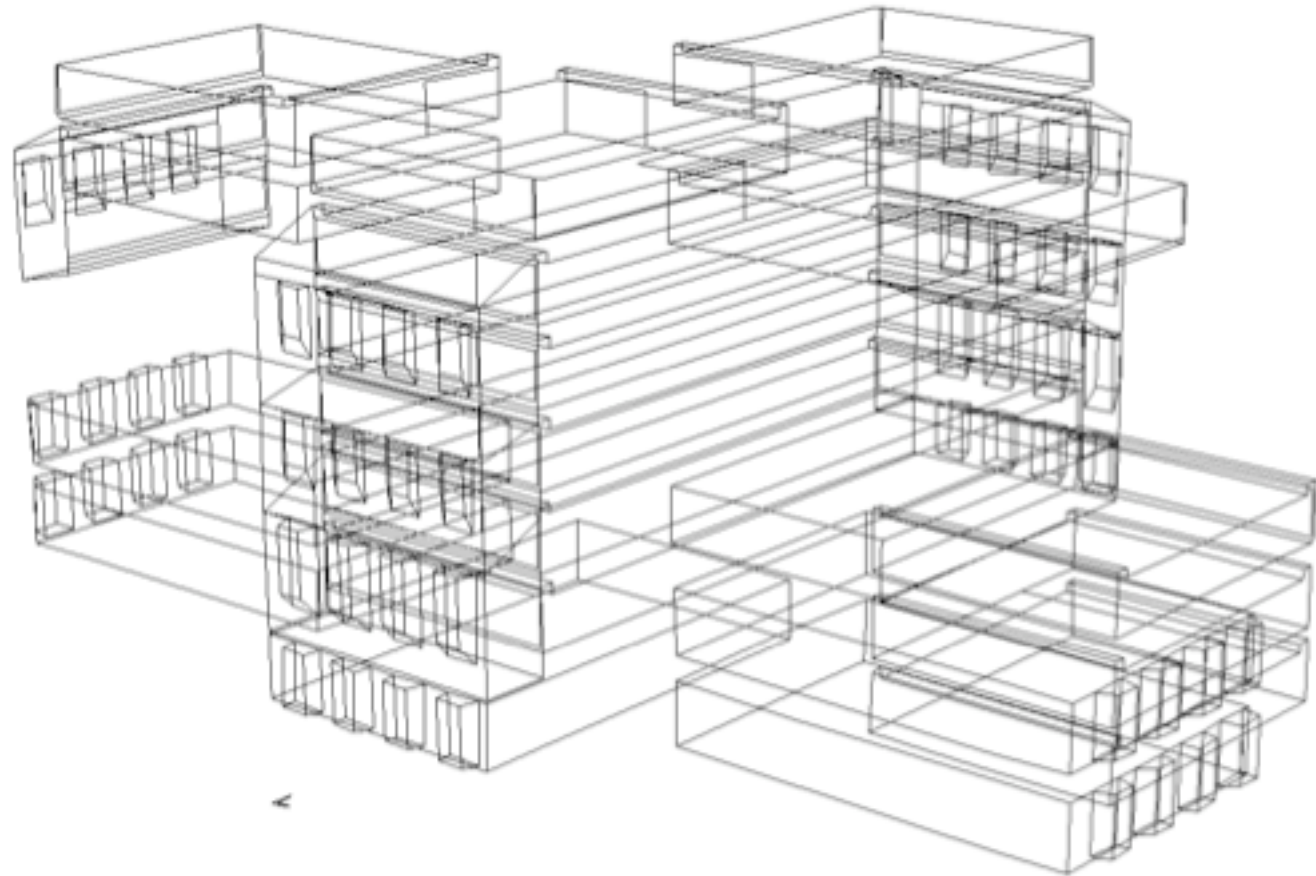- Marketed as a green building

- Buffer space
- Five story façade with seven story inside
- Daylighting vs space use vs option for heat extraction

- Model typical sections
- Include air flow analysis
- Worked with Mechanical Engineer to find an equivalent air gap resistance for buffer space and to prove it worked better than a conventional design.

Another project…

Conversion of courtyards into glazed circulation spaces

- Use of simulation to provide boundary conditions for CFD analysis

4.4   Climate concept

Based upon these results of daylight simulations we did some thermal simulation with ESP-r for calculating the temperatures in the atrium during hot summer days.
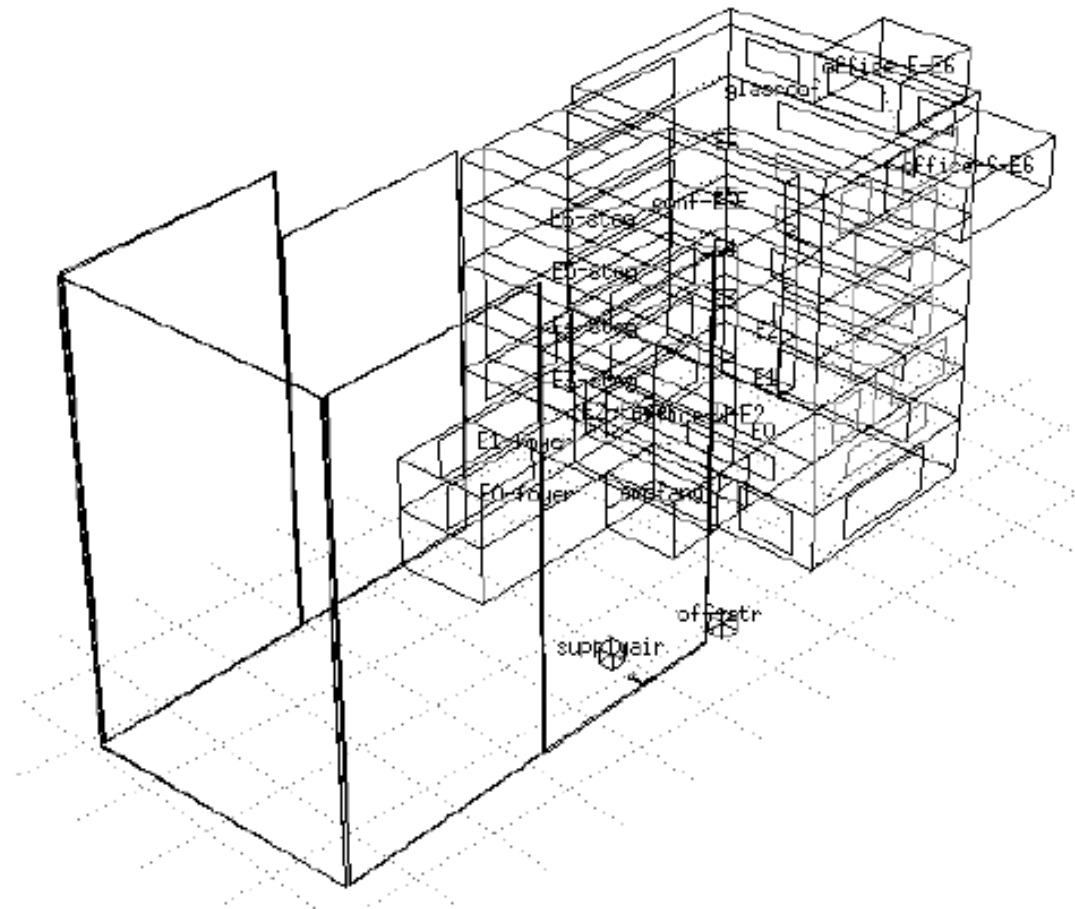
As we could not use a strong, high selective sun protection glazing, it was clear that we will need an internal shading at the roof and an external shading at the vertical glaz façade for reducing the atrium´s solar heat gain; the internal shading was positioned beyond the exhaust air device for avoiding warm air bulk between shading and glaz roof, thus minimizing thermal heat load via radiation down to floor.

Verglasungs- und Sonnenschutzkonzept
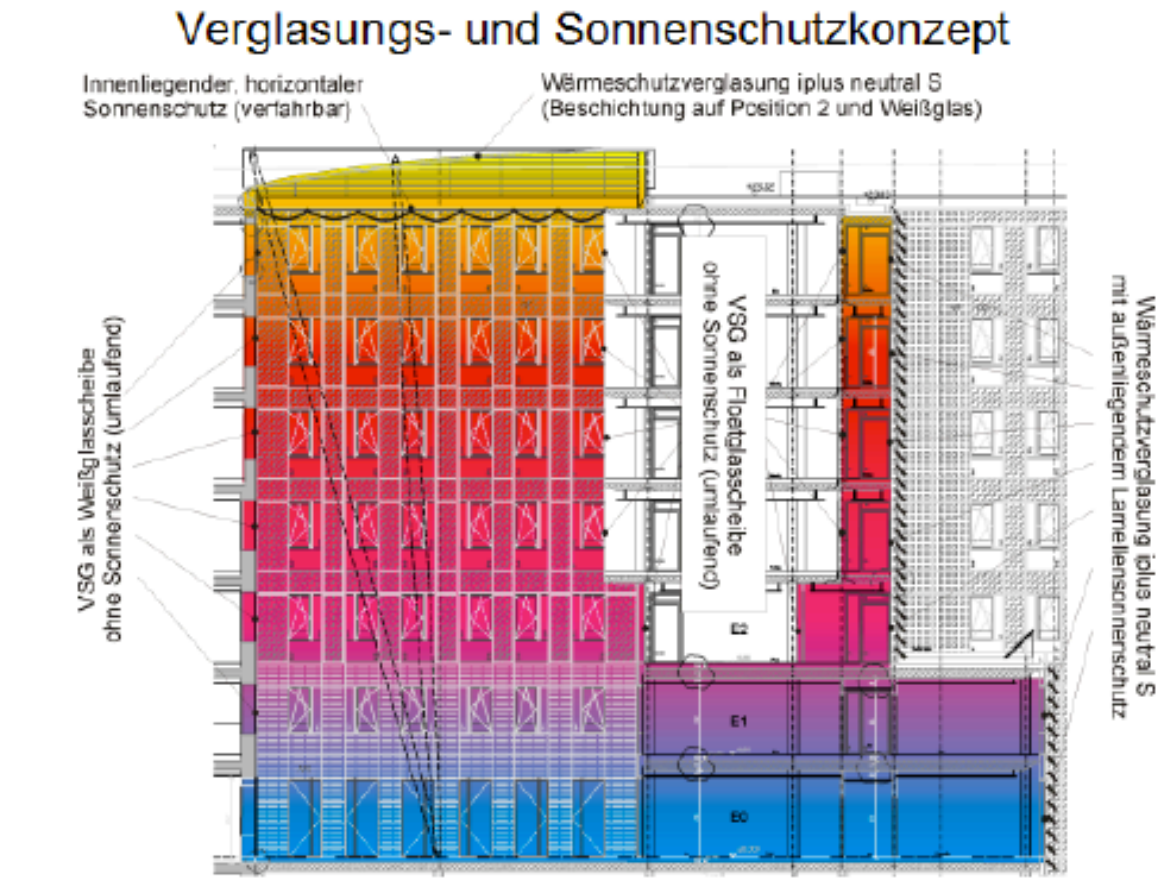
- Assessments only model a section of the building
- Scale predictions
- Use visual simulation to support lighting analysis

4.4.1 Simulation modell

All the thermal simulations, which were necessary for the development of the optimized climate concept, we did with ESP –r : It was a little bit complex model (I have sent it to you) ......

- Simulation allowed balanced design.
- Client found virtual building well represented the actual building.
- Consultant is using what was learned in the next project.

5 Finished building

Some days ago the building with the atrium has been finished; the architect as well as the client were very enthusiastic about the building – and especiall about it´s atrium ...

A look at the completely glazed facades ......

What could ESRU contribute?

- We can train and provide methodological support to those wishing to use simulation to support Annex tasks
- We can help evolve ESP-r to better support screening tasks and work with others to define that evolution
- We can act as technical consultants to Annex members.
- The UK likely has several design teams and buildings which could act as case studies
- We can work with other tool developers to ensure the equivalence of models used to support the IT tool kit.

ESRU caveats

- We do not yet have funding and it appears to be rather difficult for University groups to find funding by the normal channels….in the UK

- Suggestions on alternative funding sources, contact information and recommendations are requested.

- How about a PhD fellowship focused on Annex 46 issues?